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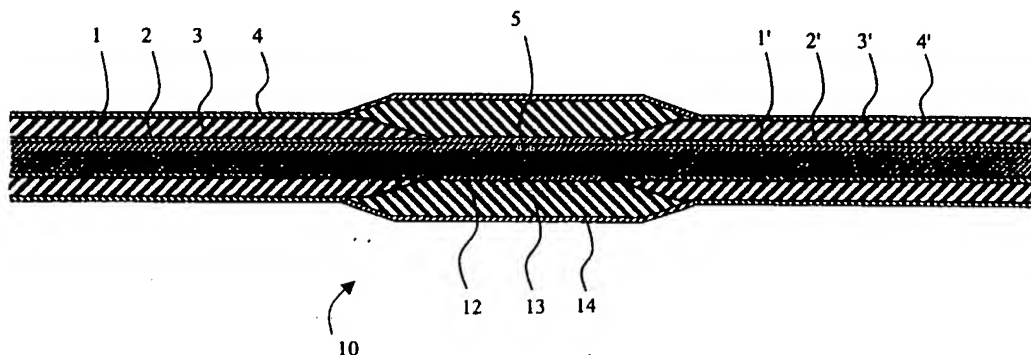
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(54) **An insulating cable connection**

(57) The invention consists of an insulating cable connection for joining an insulated electric power cable with a cable means, said electric cable comprising a wire conductor with a polymer based insulation system around said wire conductor, wherein the cable connection comprises a connection insulation system covering a wire conductor joint portion, wherein the connection

insulation system is produced in the same polymer material selection as the insulation system of the first electric cable. By an insulating cable connection according to the invention, a more homogeneous electrical field in the longitudinal direction of the cable is obtained. Thus, a cable connection according to the invention results in an electrically stronger cable connection and a more robust insulating cable connection for high-voltage cables.



*Fig. 1*

## Description

**[0001]** The present invention relates to an insulating cable connection for joining an insulated electric power cable to second cable means, said electric cable comprising a wire conductor with a polymer based insulation system around said wire conductor, where the cable connection comprises a connection insulation system covering a wire conductor joint portion.

**[0002]** A high-voltage cable comprises an electrically conducting wire core that carries the load currents. Around the conducting core an insulation system is provided. This insulation system comprises an inner semi-conducting shield in order to ensure as even a distribution of the electric field as possible in the insulation. Outside the inner semi-conducting shield an insulation is provided. On the outside of the insulation, a second outer semi-conducting shield is provided for providing an even distribution of the electric field and for retaining space charges that accumulate in the insulation.

**[0003]** Cross-linked polyethylene (XLPE) compositions are often used for the insulation system in power cables, since these materials allow for an increase in the electrical strength, a high operating temperature, improvement in handling and a good resistance to wear and tear. In WO 99/44207, a DC cable is described with a reduced tendency for space charge accumulation in the transitions between the layers in the cable, in particular around the semi-conducting shields. The advantage of reducing the space charges is that the DC voltage stress on the cable is reduced and thus allows for an increase in operation voltage or a reduction in the dimensions of the insulation thickness. Other examples of electrically insulating polymer compositions are also described in EP-A-0 674 325.

**[0004]** When the high-voltage cable is joined with another cable or with a termination or other cable accessories, the wire conductor is stripped from its insulation at the cable end section and joined with another conductor by welding, soldering or compression, depending on the type of electric conductor. The insulation is then re-established around the conductor. Methods of producing such insulating cable connections are known from e.g. US-A-4,828,634 or EP-A-0088450. Other methods for connecting cables are known from Danish patent Nos. 139859 and 140037.

**[0005]** In the cable connection space charges will also occur. Such charges will accumulate between the cable insulation system and the connection insulation system causing a decrease in the electrical strength of the cable connection that results in a decrease in the operation voltage allowed in the cables that have been joined.

**[0006]** In this light, it is the object of the invention to provide an insulation cable connection that reduces the tendency for space accumulation in the connection portion.

**[0007]** This object is achieved by an insulating cable connection of the initially mentioned kind wherein the

connection insulation system is produced in the same polymer material selection as the insulation system of the electric cable.

**[0008]** By using the same polymer materials for the insulation system in the insulating cable connection as is used in the cable itself, the space charge accumulations will be reduced since it is ensured that the electrical properties of the polymer material will always be the same. By an insulating cable connection according to the invention, a more homogeneous electrical field in the longitudinal direction of the cable is obtained. The tendency of developing polarised a space charge profile in the longitudinal direction of the cable is thus reduced in the polymer based insulation systems of the cable and the connection portions. Thus, a cable connection according to the invention results in an electrically stronger cable connection and a more robust insulating cable connection for high-voltage cables.

**[0009]** A connection insulation system of the cable connection according to the invention is designed in correspondence with the power cable to be joined and comprises an inner semi-conducting shield around the outside of the wire conductor and the inside of a conductor insulation and an outer semi-conducting shield outside the conductor insulation.

**[0010]** In the preferred embodiment, the connection insulation system is at least partly produced by moulding wherein the conductor insulation of the connection insulation system is extruded. The inner and/or the outer semi-conducting shield could also be produced by extrusion or other types of moulding. By extruding the polymer insulation, a homogeneous insulation is ensured and, in turn, a good performance and stability of the cable insulation system is provided. Extruding the components of the connection insulation system can be carried out simultaneously or by extruding and/or otherwise moulding the individual layers separately.

**[0011]** In an alternative solution, the connection insulation system is at least partly produced by at least one tape strip wound around the wire conductor connection. The inner and/or the outer semi-conducting shield is made up by said tape strip(s). The conductor insulation of the connection insulation system could be made up by one or more tape strips wound around the wire conductor connection. The use of premanufactured tape strips could be preferable under some circumstances, such as if the location on which the connection is to be carried out is remote or inaccessible for extrusion moulding equipment.

**[0012]** In the preferred embodiment of the invention, the connection insulation system is made of cross-linked polyethylene, XLPE, based composition, and particularly advantageously the XLPE based composition would comprise a polar modification in the form of a polar segment comprising a polar co-monomer. The use of a polymer of this selection can ensure a particularly low space charge accumulation not only in the cable connection but in the cable assembly as a whole.

[0013] The electric power cable to which the insulating cable connection according to the invention is used would preferably be a DC power cable, but could alternatively be a AC power cable.

[0014] The invention is described in detail with reference to the accompanying drawing in which a schematic cross-sectional view of an insulating cable connection is shown.

[0015] The figure shows an insulating cable connection joining a first cable with a second cable. However, an insulating cable connection according to the invention can also be used for establishment of a stress grading cone, such as a cable accessory, e.g. a cable termination.

[0016] The electric conductors 1, 1' are surrounded by respective insulation systems comprising the inner semi-conducting shields 2, 2', the insulation layers 3, 3' and the outer semi-conducting shields 4, 4'. The end portions of the insulation layers have been removed prior to connecting the ends of the conductors 1, 1' together by welding and the insulating cable connection 10 is provided in order to re-establish the cable insulation around the wire conductors 1, 1'.

[0017] First, the inner semi-conducting shield 12 in the insulating connection is established, preferably by placing a moulding tool comprising two form parts around the conductors 1, 1' and extruding polymer material into the form. A similar process is used for re-establishing the other layers, i.e. the connecting insulation 13 and the outer semi-conducting shield 14.

[0018] The polymer material used in the insulating cable connection corresponds to the material used in the cable insulation. This material can be chosen from variety of electrically insulating polymer materials suitable for extrusion. In the preferred embodiment of the invention, an XLPE composition is used. This material is very suitable for an extruded cross-linked cable insulation system due to its material characteristics and it can be used to mould an insulating cable connection on site for joining cables together. In order to minimise the accumulation of space charges in the insulation system, an XLPE material having a low amount of a polar co-monomer implemented into the polyethylene chain is used.

[0019] In the figure, the connection is illustrated by a larger diameter than the cable itself. However, it is realised that for DC cables it is preferable that the diameter of the insulating cable connection is substantially the same as that of the cable due to the longitudinal gradients in the polarised space charge profile.

[0020] However, it is realised that other materials can be used without deriving from the scope of the invention some of which are described in the accompanying claims. The cable assembly is also provided with a metallic lead sheath and an outer covering arranged around the outside of the lead sheath (not shown). These layers are naturally also re-established.

## Claims

1. An insulating cable connection for connecting an insulated electric power cable with second cable means, said electric cable comprising a wire conductor with a polymer based insulation system around said wire conductor, where the cable connection comprises a connection insulation system covering a wire conductor joint portion,  
**characterised in that**  
the connection insulation system is produced in the same polymer material selection as the insulation system of the electric cable.
2. An insulating cable connection according to claim 1, wherein the connection insulation system comprises an inner semi-conducting shield around the outside of the wire conductor and the inside of a conductor insulation and an outer semi-conducting shield outside the conductor insulation.
3. An insulating cable connection according to claim 1 or 2, wherein the connection insulation system is at least partly produced by moulding.
4. An insulating cable connection according to claim 3, wherein the conductor insulation of the connection insulation system is extruded.
5. An insulating cable connection according to claim 3, wherein the inner and/or the outer semi-conducting shield is produced by extrusion or other types of moulding.
6. An insulating cable connection according to claim 1 or 2, wherein the connection insulation system is at least partly produced by at least one tape strip wound around the wire conductor connection.
7. An insulating cable connection according to claim 6, wherein the inner and/or the outer semi-conducting shield is made up by said tape strip(s).
8. An insulating cable connection according to claim 6 or 7, wherein the conductor insulation of the connection insulation system is made up by one or more tape strips wound around the wire conductor connection.
9. An insulating cable connection according to any of the previous claims, wherein the connection insulation system is made of cross-linked polyethylene, XLPE, based composition.
10. An insulating cable connection according to claim 9, wherein the XLPE based composition comprises a polar modification in the form of a polar segment comprising a polar co-monomer.

11. An insulating cable connection according to any of the previous claims, wherein the diameter of the insulating cable connection is essentially similar to the diameter of the electric cable. 5
12. An insulating cable connection according to any of the previous claims, wherein the electric power cable is a DC power cable.
13. An insulating cable connection according to any of claims 1 to 11, wherein the electric power cable is a AC power cable. 10
14. An insulating cable connection according to any of the previous claims, wherein the second cable means is a cable termination. 15
15. An insulating cable connection according to any of claims 1 to 13, wherein the second cable means is a second electric cable. 20

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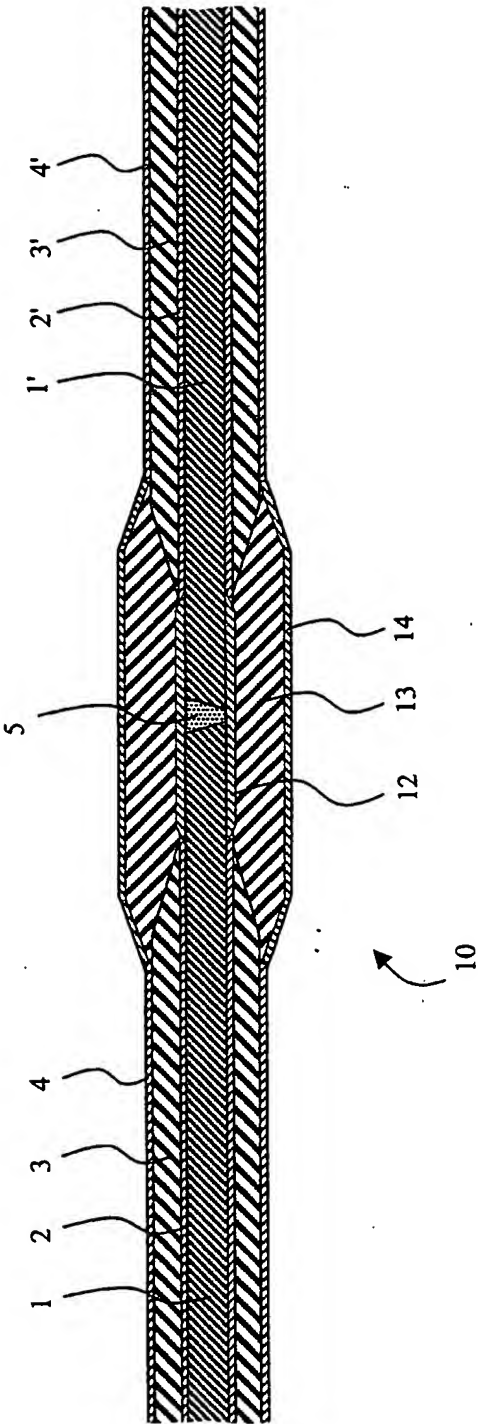


Fig. 1



European Patent  
Office

## EUROPEAN SEARCH REPORT

Application Number  
EP 00 20 0627

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	EP 0 312 424 A (STANDARD TEL KABELFAB AS) 19 April 1989 (1989-04-19) * column 2, line 10 - line 28; figure 1 *	1,2,9, 11,13,15	H02G15/184 H02G15/103 H02G1/14
X	FR 2 431 784 A (SUMITOMO ELECTRIC INDUSTRIES) 15 February 1980 (1980-02-15) * page 4, line 11 - page 5, line 2; figure 1 *	1-5, 9-11,13, 15	
X	US 3 801 730 A (STARR W ET AL) 2 April 1974 (1974-04-02) * column 2, line 63 - column 3, line 48; figures 1-4 *	1-5,9, 13,15	
X	GB 773 832 A (BICC) 1 May 1957 (1957-05-01) * the whole document *	1-5,9, 13,15	
A	EP 0 886 342 A (ALSTHOM CGE ALCATEL) 23 December 1998 (1998-12-23) * column 1 - column 2; figure 1 *	1,2,6, 11-13,15	TECHNICAL FIELDS SEARCHED (Int.Cl.7)
A	DE 25 55 305 A (KABEL & LACKDRAHTFAB GMBH) 1 July 1976 (1976-07-01) * page 5, last paragraph - page 8, paragraph 1; claims 1,2; figures 1,2 *	1,2,15	H02G
A	GB 921 901 A (THE TELEGRAPH CONSTRUCTION & MAINTENANCE COMPANY) 27 March 1963 (1963-03-27) * page 1, line 19 - line 28 *	1-3,15	
A,D	US 4 828 634 A (NIELSEN OLE K) 9 May 1989 (1989-05-09)		
A,D	EP 0 088 450 A (FURUKAWA ELECTRIC CO LTD) 14 September 1983 (1983-09-14)		
The present search report has been drawn up for all claims			
Place of search <b>THE HAGUE</b>		Date of completion of the search <b>30 June 2000</b>	Examiner <b>Lommel, A</b>
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	
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EPO FORM 1503 (03.02.92) (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.**

EP 00 20 0627

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on  
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

30-06-2000

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
EP 0312424	A	19-04-1989	NO 874258 A	14-04-1989
			AT 102760 T	15-03-1994
			DE 3888280 D	14-04-1994
			DE 3888280 T	01-12-1994
			DK 568388 A, B,	14-04-1989
			ES 2049759 T	01-05-1994
			JP 1164211 A	28-06-1989
			JP 1940190 C	09-06-1995
			JP 6067085 B	24-08-1994
			KR 9705285 B	15-04-1997
			US 4855536 A	08-08-1989
FR 2431784	A	15-02-1980	JP 55155483 A	03-12-1980
			JP 1172260 C	17-10-1983
			JP 55013690 A	30-01-1980
			JP 57026045 B	02-06-1982
			JP 1309784 C	26-03-1986
			JP 55030175 A	03-03-1980
			JP 60032956 B	31-07-1985
			JP 1339320 C	29-09-1986
			JP 55057283 A	26-04-1980
			JP 60042597 B	24-09-1985
			DE 2928856 A	21-02-1980
			FI 792227 A, B,	18-01-1980
			GB 2030014 A, B	26-03-1980
			NL 7905516 A, B,	21-01-1980
			US 4289721 A	15-09-1981
US 3801730	A	02-04-1974	NONE	
GB 773832	A		NONE	
EP 0886342	A	23-12-1998	NONE	
DE 2555305	A	01-07-1976	SE 387206 B	30-08-1976
			SE 7415722 A	17-06-1976
GB 921901	A		NONE	
US 4828634	A	09-05-1989	DK 210986 A	24-02-1988
			CA 1276436 A	20-11-1990
			DE 3780447 A	20-08-1992
			DE 3780447 T	04-03-1993
			WO 8707095 A	19-11-1987
			EP 0286645 A	19-10-1988
			FI 875665 A, B,	22-12-1987

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

**ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.**

EP 00 20 0627

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on  
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

30-06-2000

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4828634 A		NO 880037 A, B,	06-01-1988
EP 0088450 A	14-09-1983	JP 1032730 B	10-07-1989
		JP 1549639 C	09-03-1990
		JP 58157318 A	19-09-1983
		DE 3361147 D	12-12-1985
		US 4458103 A	03-07-1984

EPO FORM P4499

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82